Soil Interpretations for Intensive Forest Biomass Harvesting

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ABSTRACT
Intensive forest harvesting for traditional wood products and for the emerging biomass and biofuel markets has the potential to decrease soil quality. Site productivity and sustainability will be key issues as timber rotation ages decrease and production increases due to demand. The goal of the international Long-Term Soil Productivity study, with over 100 field locations in North America, is to develop soil quality guidelines across large areas and site gradients with respect to harvesting treatments. Data could be used in conjunction with mappable soil information, such as geology, land form, and soil type to develop risk maps of productivity decline due to intensive harvesting. This study provides a unique opportunity to supply information of long-term impacts across soil types with differing forest management practices. Potential uses of this data will be presented across a site gradient in the Western Gulf Coastal Plain.

INTRODUCTION
Tree crowns and small diameter trees, left on site as harvesting slash, hold a remarkably large amount of nutrients. Timber harvesting for bioenergy would involve off-site removal of tree crowns and small diameter trees, causing a reduction in soil productivity. Soil productivity is a vital factor in forest productivity and timber yield. As the markets for biomass and biofuel emerge, demands for timber production will increase, and increased demand may shorten timber rotation age, further amplifying long-term impacts. Therefore, site productivity and sustainability will be key issues for landowners, especially on lands where fertilization is not a common management practice. A soil-based rating system is necessary to provide landowners and forest managers information to ensure intensive biomass harvesting does not reduce soil productivity.

The international Long-Term Soil Productivity (LTSP) study was initiated by the USDA Forest Service to research and monitor the impacts of forest management on long-term soil productivity. Program cooperators include US National Forest System, US Forest Service Research, Canadian Forest Service, British Columbia Ministry of Forests, Ontario Ministry of Natural Resources, universities, and industry. This study began in 1989 and now comprises over 100 LTSP and affiliated sites located throughout the US and within Canada (Figure 1). Sites range over a diversity of forest ecosystems, age-classes, and soil conditions that are likely to be under forest management.

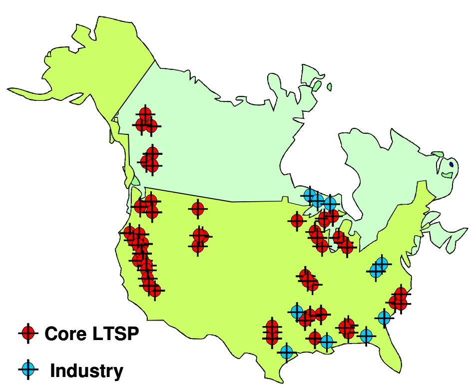

Figure 1: LTSP and affiliated site locations.

Soil and site processes control site productivity, and soil organic matter and porosity, which regulates critical soil processes, are directly affected by management. LTSP's hypotheses target manipulation of these two key soil variables, with the objectives to: *i*. quantify the effects of soil disturbance on soil productivity, *ii*. validate standards and method for soil quality monitoring, *iii*. understand the fundamental relationships between soil properties, long-term productivity, and forest management practices, and *iv*. evaluate the potential for mitigating the adverse effects of disturbance. Organic matter removal and compaction treatments (3x3 factorial) have been applied to LTSP sites. Organic matter removal treatments include tree bole only (crowns, felled woody and herbaceous understory, and forest floor retained on site), whole-tree removal (tree boles and crowns removed with felled woody and herbaceous understory, and forest floor retained on site), and total removal (all aboveground biomass removed to bare mineral soil). Compaction treatments are no compaction, compacted to intermediate bulk density, and compacted to unusually high bulk density. Main soil physical variables, such as soil loss and soil bulk density, and soil chemical properties, such as soil nutrient status and cycling, are being monitored.

Forest harvesting is just one factor affecting soil productivity. Regional factors, such as climate, atmospheric deposition, or geography, and local factors, such as inherent soil nutrient deficiencies, erosion, or land use history, compound the impact of harvesting on soil productivity. LTSP has the ability to address these additional factors because of the extent of the variability of the research sites across the US and Canada. We propose the development of risk maps of potential productivity decline due to intensive harvesting. Data from LTSP could be used in conjunction with mappable soil information such as soil morphological, geological, and cultural influences on soil fertility to create such maps.

METHODS

The proposed risk assessment maps for maintaining site productivity would be produced using the following information:

i. Existing information from the LTSP studies and other established studies to develop guidelines for soil ratings for the sustainability of intensive biomass harvesting
ii. Use the existing NASIS database from the USDA NRCS and laboratory soil chemistry studies to develop a soil fertility model based on soil taxonomy and morphology, parent material, and land use history
iii. Merge the soil ratings with soil fertility maps to create maps of soil susceptibility to productivity losses following intensive biomass harvesting
iv. Verify the model and susceptibility ratings on multiple operational trials

BENEFITS

This proposed research will help to ensure maintenance of soil productivity on sites undergoing biomass harvesting, especially on timberland that is not fertilized. Many landowners cannot afford or choose to manage forested lands within inherent nutrient limitations, especially if timber production is not the primary management objective. Intensive biomass harvesting has the potential to increase in rural areas due to market demand, but long-term reduction in soil productivity could cause these markets to be non-sustainable. Few silvicultural tools help forest managers to assess the impacts of harvesting on productivity of poor quality land. This proposed research would develop the tools needed to ensure that soils with a high-risk of productivity decline would be identified so that management practices could be modified.

Soil properties, especially soil chemical properties, will differ not only by soil series but also by past land uses and management practices. And example of differences in extractable phosphorus (P) within a soil series is shown in Figure 2 (C. Bliss, unpublished data from the Santa Fe River Watershed in Florida). This supports the importance of the readily available, large database from LTSP which provides needed information for both regional and localized ecosystems. An example of available data from LTSP on site productivity impacts due to intensive harvesting is shown from data collected from 10 LTSP sites in the western Gulf coastal plain. Whole-tree harvesting has been found to reduce productivity an average of 19% on unfertilized loblolly pine sites at age 10, with losses of up to 40% on sites with initially low pre-harvest extractable P (Scott and Dean 2006), showing the potential long-term impact of intensive harvesting. This data provides needed information on intensive management impacts across a soil gradient (fertility, hydrology, morphology) involving 6 soil series and will be used to show potential risk maps.

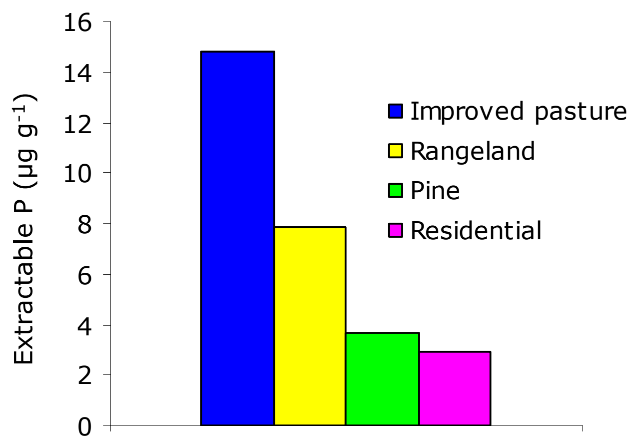

Figure 2: Differences in extractable P (0-10 cm depth) by land use in the Mascotte soil series.

The proposed risk maps would provide needed information to landowners and managers on the potential long-term impact on soil productivity due to biomass harvesting. LTSP not only provides regional data on key soil properties impacted by intensive harvesting, but also on more localized characteristics, such as inherent low soil fertility. This data could be used in conjunction with mappable soil information, such as geology, land form, and soil type, to develop risk maps of productivity decline due to intensive harvesting. The proposed study provides is a unique opportunity to supply information of long-term impacts across soil types with differing forest management practices to landowners and managers, especially on sites that rely on inherent soil properties for sustainability.

REFERENCES

Scott, D.A., and T.J. Dean. 2006. Energy trade-offs between intensive biomass utilization, site productivity loss, and ameliorative treatments in loblolly pine plantations. Biomass Bioenergy. 30:1001-1010.

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